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Bed occupancy and hospital mortality

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It has been commonly observed that bed occupancy above 85% leads to increased risk of hospital acquired infection, serious errors, staff consumption of antidepressants and higher mortality (Kaier et al 2010, Jones 2011, Boyle et al 2013, Jones 2013, Teitelbaum et al 2016). The effect is not due to occupancy *per se* but from generally poorer staff to patient ratios resulting in increased business and consequent reduction in hygiene standards, increased errors, patient falls and never events (Kaier et al 2012, Boyle et al 2013, Kuntz et al 2014). These match with the observation that poorly resourced hospitals generally have higher mortality rates (Griffiths et al 2015, Ozdemir et al 2016).

In a previous 'Money Matters' a relationship between all-cause mortality and hospital occupancy was noted with all-cause mortality seeming to increase hospital occupancy and not vice versa (Jones 2016a). Several people have challenged this relationship suggesting that it was an increase in occupancy that led to the increase in all-cause mortality. This alternative suggestion is unlikely for several reasons. Firstly in-hospital deaths in England only account for 47% of total deaths (Public Health England 2016), and the observed increase in all-cause mortality was far too high to be attributed solely to in-hospital deaths. Indeed the data presented in the previous study implied that a 1% point step-increase in occupancy implied a huge 3% to 9% increase in all-cause mortality. Secondly, the explanation based on occupancy does not explain the unique step-like changes in both occupancy and deaths previously presented (Jones 2016).

To my knowledge no one has ever demonstrated how in-hospital mortality may respond to changes in occupancy over the range of occupancies commonly seen in acute hospitals. The strength of such a relationship can be explored using two data sources available for English hospitals. The first are quarterly reported occupancy in English hospitals available from NHS England (2016) and the second is Summary Hospital-level Mortality Indicator (SHMI) data for English hospitals available from the Health and Social Care Information Centre (2016). SMHI (which also includes deaths within 30 days of discharge) is calculated every quarter using 12 months of data and hence hospital occupancy was re-calculated on the same basis. The SHMI data for 141 acute hospitals was available covering 10 quarterly increments for the year ending Jun-13 through to year ending Sep-15 and this was matched with the occupancy data over the same period. The majority of SHMI values lie in the range 1.0 ± 0.2 and a minority of values below 0.8 were removed as outliers giving 1,200 occupancy-SMHI combinations. Data was then ranked in 0.1% increments of occupancy and the average SHMI was then calculated for each occupancy bin. The result of this analysis is presented in Figure 1 where it can be seen that there is an approximate linear relationship between SHMI and occupancy. However occupancy *per se* can only

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explain 38% of the observed variance, i.e. the unmeasured staff to patient ratios is most likely to explain much of the remaining 62% of the variance.

Figure 1: Relationship between annual SHMI and occupancy between June 2013 and September 2015 in 141 English acute hospitals

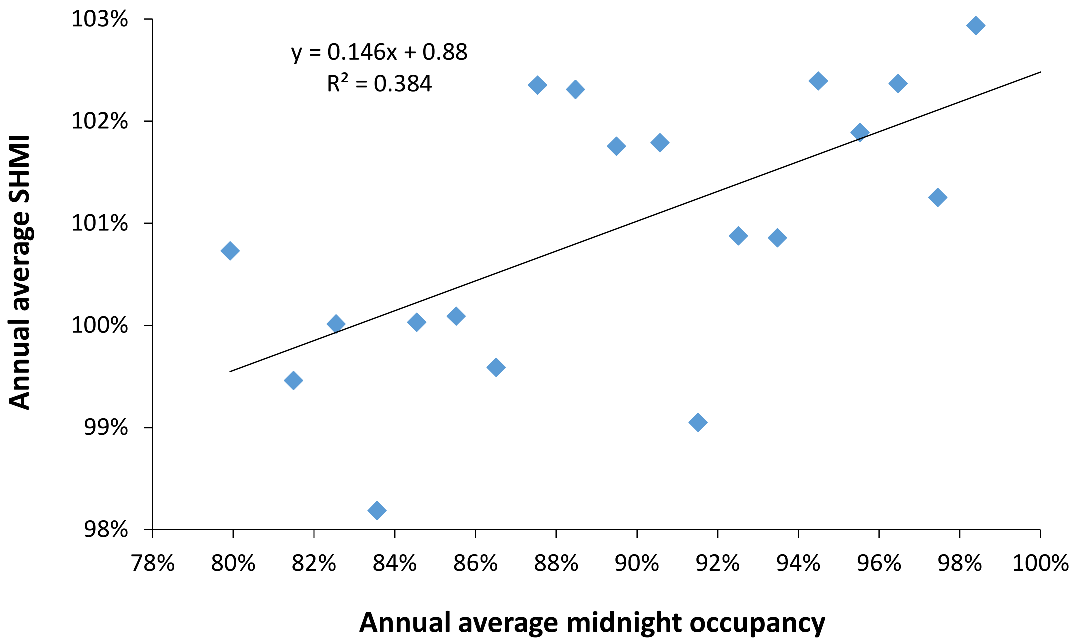
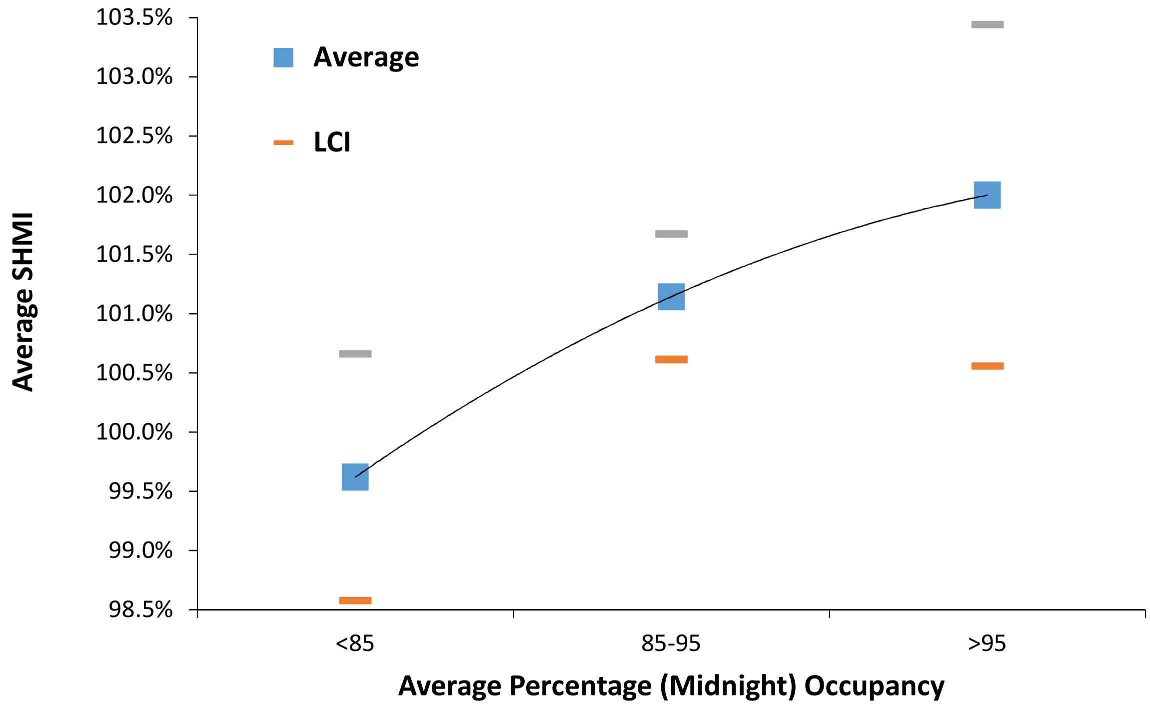


Figure 2: Alternative analysis with data aggregated into three occupancy bins



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However, the key point is that it takes a 10% point increase in annual average occupancy to make a 1.5% point increase in hospital deaths (including death within 30 days of discharge) – which is vastly smaller than a figure of 30% to 90% implied in the previous study (Jones 2016a). It could be argued that the strength of this relationship has been underestimated, since other studies have used daily occupancy to study the impact on hospital errors and deaths (Boyle et al 2013), however underestimation by 20- to 60-fold is beyond the realms of feasibility.

Visual inspection of Figure 1 reveals some evidence that SHMI may in fact jump above 85% occupancy. An alternative analysis of the data leads to Figure 2 where a non-linear relationship exists above 85% occupancy. The lower confidence interval (UCI) and upper confidence interval (UCI) shown in Figure 2 are based on the standard error of the mean. This alternative suggests that it is only when a hospital crosses the 85% threshold that occupancy becomes an issue, and even then the slope of the relationship is less than that in Figure 1.

We are therefore left with the original proposal that sudden and large step-increases in all-cause mortality act via their effect on emergency medical admissions (Jones 2015, 2016b) to increase average occupancy. The increased occupancy resulting from whatever is causing the increase in deaths and admissions will only make a tiny contribution to in-hospital deaths and thus to all-cause mortality. The focus therefore needs to be on the presumed infectious agent capable of inducing such large and sudden increases in death and hospital admissions (Jones 2015, 2016b).

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